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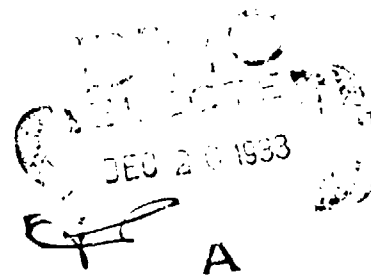


**USN/USAF
ANTI-G-SUIT
CONSOLIDATION PROGRAM**

Jules Z. Lewyckyj
Aircraft and Crew Systems Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, PA 18974

22 AUGUST 1983

FINAL REPORT



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) As a result of a Standardization meeting between the US Air Force and the US Navy, it was decided that a joint specification would be prepared for an Anti-G Suit. To this end, each service would evaluate the other Services Anti-G Suit and the best features would be combined. This report provides some of the background and a comparison of both suits. It provides a test program on the Air Force CSU-13/P Anti-G Suit to be conducted by NAVAIRDEVCON.		

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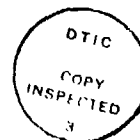
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BACKGROUND

A consolidation/Standardization Meeting on an Anti-Gravity (G) garment was held at the Naval Air Development Center (NAVAIRDEVCON), Warminster, PA on 25 February, 1982 between the United States Air Force (USAF) and United States Navy (USN). The purpose of the meeting consisted of trying to prepare a joint, consolidated specification through the exchange and operational testing and evaluation of each others most current, service qualified Anti-G garment. Therefore, NAVAIRDEVCON will make an evaluation/comparison of the USAF CSU-13/P Anti-G garment and include its best features into the joint specification, just as the Air Force will make a comparison of the Navy Anti-G garment (CSU-15/P).

DESCRIPTION

The CSU-13/P Anti-G garment is used by the Air Force to give aircrew members flying in high performance aircraft enhanced protection from high-G forces. The garment is an air-inflated, constricting garment that is constructed of polyurethane-coated, nylon cloth bladder covered by an outer shell of light weight, 95/5 Nomex/Kevlar blend material (MIL-C-83429).

As stated in reference A, the bladders of the CSU-13/P series cutaway garment are inflated automatically by means of a metering valve during maneuvers involving positive forces of two or more "Gs." The pressure applied by the garment to the user's body is proportional to the "Gs." Positive "G" force is defined as a force acting on the body in a direction from head to foot. It is usually encountered when pulling out of a dive or in a turn while in the seated position. Symptoms of positive "G" forces (average values after ten seconds application) are: 1G-normal; 2G-feeling of being pressed in seat; 3G-impossible to get out of seat and difficult to move arms; 3 to 4Gs-gray out (dimming of vision and loss of side vision); 4 to 5Gs-loss of vision or blackout; 5 to 6Gs-unconsciousness. The anti-G garment provides about two G's extra protection. The resulting pressurization of the abdominal and leg regions ensures an adequate blood supply to the upper body and head by counteracting the drawing of the blood from the head and chest into the lower part of the body under high "G" forces, thus preserving circulation, visual activity and mental alertness. The bladders deflate when level flight is resumed.

The major differences between USAF (CSU-13/P) and USN (CSU-15/P) designs are as follows:

- a) CSU-13/P leg zipper closures are conventional and close in an upward direction, as well as an eye and loop at the top and a snap at the bottom to prevent fastener separation; the USN uses a quick-release type that separates in a downward direction.
- b) CSU-13/P uses a larger bladder size and a heavier bladder cloth of urethane-coated nylon.
- c) CSU-13/P has thigh take-up zippers, and accessories of a MC-1 knife pocket and checklist retainers, while USN has no requirements for these items.
- d) CSU-13/P attachment hose length is 17 inches versus 22 inches on the USN Anti-G garment.
- e) CSU-13/P uses hook and pile fasteners for thigh lacing covers while Navy uses a light nylon coil slide fastener.

- f) CSU-13/P has an age limitation of 12 months from manufacture to delivery of material versus 18 months for the USN.
- g) Contractor performs own first article test witnessed by Defense Contract Administration Service for CSU-13/P prior to delivery, versus private testing laboratory tests for USN units after delivery of the units.
- h) The CSU-13/P has a large extra long size while the Navy is considering a small short size for women.

NOTE: A complete comparison chart, between the AF CSU-13/P and Navy CSU-15/P Anti-G garment for all similarities/differences is given in Appendix A.

OPERATIONAL TEST CONCEPT

Since both suits perform similar functions, the CWU-13/P and its unique features will be operationally evaluated against current concepts applicable to Navy Anti-G garments. NAVAIR-DEVCEN proposed a Program Management Summary of Research and Development efforts that is shown in Appendix B. Intermediate and Depot level maintenance are not required for these tests. CSU-13/P garments may also be repaired by organizational level maintenance personnel in accordance with (IAW) USAF technical data (Ref. A). Defective garments that cannot be repaired IAW USAF technical data will be removed from service and returned to Aircraft and Crew Systems Technology Directorate (CODE 60335), NAVAIRDEVCEN, Warminster, PA 18974. Logistics support for the CSU-13/P will be provided through NAVAIRDEVCEN. The Navy has previously evaluated its own garment (Ref. B) which is reported in Ref. C.

TEST OBJECTIVES

1. Appraise the ease of donning and doffing the CSU-13/P as compared with the current Navy Anti-G garment.
2. Appraise the comfort and fit of the CSU-13/P as compared with current Navy Anti-G garment.
3. Appraise the capability of the CSU-13/P to provide G protection as compared with the current Navy Anti-G garment.
4. Appraise the compatability of the CSU-13/P with other life support and aircraft equipment as compared with the current Navy Anti-G garment.
5. Appraise the durability of the CSU-13/P as compared with the current Navy Anti-G garment.
6. Appraise the selected design features of the CSU-13/P that differ from current Navy Anti-G garments.

PURPOSE & SCOPE

The purpose of these tests is to evaluate the operational effectiveness and suitability of the CSU-13/P to both the aircrewmen and the technicians. Results will be used to determine which design features of the CSU-13/P are acceptable for use in the USN/USAF consolidated garment. Acceptable design features of both the CSU-13/P and current Navy Anti-G garments (CSU-15/P) will be incorporated into a specification for a single garment, which will replace the individual USAF and USN specifications and garments presently in use.

The tests will be limited to the evaluation of 8 CSU-13/P garments. The tests should be conducted by aircrewmen on as many different types of Naval aircraft assigned to Naval Air Test Center, (NAVAIRTESTCEN), Patuxent River, MD as possible. Aircrew members and aircrew survival equipmentmen should evaluate the suits during routine flights and inspections. Durability can only be evaluated on a limited basis since hidden deficiencies may not surface during the 60 day assigned test period.

FLIGHT TESTING

Each participating aircrew member and Aircrew Survival Equipmentman shall be thoroughly briefed by NAVAIRTESTCEN personnel on the purpose of these tests. NAVAIRTESTCEN personnel will supervise all fittings and ensure that each aircrew member is properly fitted with the appropriate size garment IAW Table 1. Aircrew members flying in all Naval aircraft at all crew positions will evaluate the CSU-13/P during routine flying activities throughout the test period. At the completion of each test sortie, the aircrewmembers will complete an Aircrew Questionnaire (appendix C).

NAVAIRTESTCEN will assess the response of aircrew members to: (1) the ease of donning and doffing; (2) comfort and fit; and (3) G-protection offered by the garment.

NAVAIRTESTCEN will also assess the response of the aircrew members to: (4) compatibility with other life support and aircraft equipment (5) durability (6) various design features with particular emphasis placed on evaluating the design differences and problems with the suit.

TABLE I—Stature and Weight Ranges for Fitting of "G" Suit

	Stature Range (inches)	Weight Range (pounds)
Small regular	63.0 –67.9	131–160
Small long	68.0 –72.9	131–160
Medium regular	65.5 –69.4	161–190
Medium long	69.5 –74.4	161–190
Large regular	67.0 –71.24	191–220
Large long	71.25–75.4	191–220
Large extra long	75.5 –79.0	191–230

SUMMARY

All flight testing will be conducted in conjunction with routine flying activities. No mission will be scheduled solely in support of this project.

For planning purposes, each test participant should fly a minimum of five missions with the CSU-13/P. However, questionnaires will still be required if less than five sorties are flown. During the test, the project manager will monitor missions to ensure a reasonable number and cross-section of high-G missions are being accomplished.

Test garments will be inspected IAW USAF technical data. Preflight inspections will be performed by the aircrew member prior to each flight. The calendar inspections will be performed by Aircrew Survival Equipmentman prior to the test, every 14 days during the test, and at the end of the test.

A final NATC Report listing all the advantages/disadvantages of the Air Force CSU-13/P garment as compared to the Navy CSU-15/P garment will be issued after completion of the testing.

ACKNOWLEDGEMENT

The author acknowledges the contributions and participation of the following (and the activities with which they are associated):

<u>Name</u>	<u>Activity</u>
Ron Borman	ASD/AESO, Wright Patterson AF Base
1st Lt. Mike Wilson	AS/ENE, Wright Patterson AF Base
Harold Bless	Sanders & Thomas, Inc., Horsham, PA
Harry Brooks	ASO, Philadelphia, PA
J. Rodrigues	NATC, Patuxent River, MD
David De Simone	NADC/ACSTD, Warminster, PA
Jon Harding	NADC/ACSTD, Warminster, PA
W. Zarkowski	NADC/ACSTD, Warminster, PA
Ed Boscola	NADC/ACSTD, Warminster, PA
Al Hellman	NADC/ACSTD, Warminster, PA
Sue Reeps	NADC/ACSTD, Warminster, PA

REFERENCES

- A. Technical Manual – Use, Operation and Maintenance Anti-G Cutaway Garment Types CSU-13A/P and CSU-13B/P dated 15 October 1976 with change 7 dated 31 March 81.
- B. Manual NAVAIR 13-1-6.7 Aviation-Crew Systems Aircrew Personal Protective Equipment dated 15 Aug 1979 with change 3 dated 30 July 81.
- C. NADC Report NADC-74016-40 of 17 January 74, Operational Evaluation of the CSU-15/P Anti-G Coverall by Marcia A. Bushenski.

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APPENDIX A
ANTI-G GARMENT COMPARISON CHART
CSU-15/P AND CSU-13/P



ANTI-G GARMENT COI

CSU-15/P AN

NAVY				AF				NAVY					
ITEM DESCRIPTION		CSU-15/P		CSU-13/P		TRI-SERVICE*		ITEM DESCRIPTION		CSU-15/P			
GARMENT SIZES				LATEST USN & USAF ANTHRO- POMETRIC STUDIES & USAGE TO BE EVALUATED. NEW SIZING, IF REQUIRED				OUTERSHELL CLOTH		MIL-C-81814 ARAMID 2 2 2 TWILL 52 - 50 OZ/YD'			
SMALL SMT								COLOR		SAGE GREEN 1565			
SMALL REG		I						BLADDER		UNITHANE COATED NYLON 33 - 40 OZ/YD'			
SMALL LB		I											
MEDIUM REG		I											
MEDIUM LB		I											
LARGE REG		I											
LARGE LB		I											
LARGE 2-LB		I		SIAM TAPE		5'8 - 3'4"							
GARMENT ACCOM		6 SIZES		7 SIZES		SPACER MAT		TRILOR 6009-1-1A					
HEIGHT		64" - 78"		63" - 78"		HOSE DESIGN		FLEX HOSE WITH TRILOCK INSERT					
WEIGHT		125 - 212 LBS		131 - 231 LBS		LENGTH		22'					
FASTENER ARRANGEMENTS				USAF CHECK USN DESIGN (WITH USN SUITS) *				REINFORCEMENT AT SUIT		BLADDER CLOTH			
WAISTBAND		MEDIUM HEAVY SLIDE FASTENER LEFT HAND SEPARATING IN DOWNWARD DIRECTION						EYE AND LOOP FASTENER AND MEDIUM HEAVY SLIDE FASTENER RIGHT HAND SEPARATING IN DOWNWARD DIRECTION		SPACER SPRING		NOT REQUIRED	
LEFT LEG		MEDIUM HEAVY SLIDE FASTENER RIGHT HAND QUICK RELEASE RIGHT HAND SEPARATING IN DOWNWARD DIRECTION						MEDIUM HEAVY SLIDE FASTENER LEFT HAND SEPARATING IN UPWARD DIRECTION. SNAP FASTENER AT BOTTOM EYE AND LOOP AT TOP		GARMENT ADJ COMP			
RIGHT LEG		MEDIUM HEAVY SLIDE FASTENER LEFT HAND QUICK RELEASE. LEFT HAND SEPARATING IN DOWNWARD DIRECTION						MEDIUM HEAVY SLIDE FASTENER RIGHT HAND SEPARATING IN UPWARD DIRECTION. SNAP FASTENER AT BOTTOM EYE AND LOOP AT TOP		LOOP TAPE		BALLY RIBBON MILLS STYLE #1546 OR #2461	
LACING COVERS		LIGHT NYLON COIL SLIDE FASTENER, RIGHT OR LEFT SEPARATING		HOOK AND PILE FASTENER TYPE IV MIL T 36320		ELASTICIZED. USN CHECK HOOK AND PILE		LOOP CORD		MIL-C-81104			
SHIN POCKETS		MEDIUM SPECIAL SLIDE FASTENER. BRIDGE TOP STOP. CLOSED BOTTOM STOP		SAME AS CSU-15/P		SAME AS CSU-15/P		LACING COVERS		ELASTICIZED			
KNIFE POCKET		NO REQUIREMENT FOR POCKET		SNAP FASTENER STYLE A CONSTRUCTION A. MIL F 10884		KNIFE POCKET		WAISTBAND STIFFENERS					
THIGH TAKE-UP		NO REQUIREMENT FOR THIGH TAKE-UP		MEDIUM SPECIAL SLIDE FASTENER. OPEN TOP STOP. CLOSED BOTTOM STOP		REMOVE		FRONT		NYLON DUCK CLOTH			
CHECKLIST RETAINER		NO REQUIREMENT FOR CHECKLIST RETAINER		HOOK AND PILE FASTENER. TYPE IV MIL T 36320		USE PILE FASTENERS AS IN CSU-13/P		BACK		NYLON DUCK CLOTH			
								AGE LIMITATIONS OF MATERIALS		MANUFACTURE TO DELIVERY 18 MONTHS			
								FIRST ARTICLE TEST		TEST PERFORMED BY PRIVATE TEST FACILITY UNDER SUPERVISION OF NADC			

* USN SUITS FURNISHED
WPAFB BY NAVAIRDEVCE

** USAF SUITS FURNISHED
BY NAVAIRDEVCE B

A-1/A-2

①

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APPENDIX B
PROGRAM MANAGEMENT SUMMARY OF RESEARCH
& DEVELOPMENT EFFORTS

PROGRAM MANAGEMENT SUMMARY OF RESEARCH & DEVELOPMENT EFFORTS

Program Element No.: <u>64264N</u>		Task Area Title: <u>Aircrew Life Support Systems</u>	
Sub-Task Title: <u>USN/USAF Anti-G Garment Standardization</u>			
Program Status:	On-going <input type="checkbox"/>	Proposed <input type="checkbox"/>	Planned <input checked="" type="checkbox"/> Date: <u>2 Dec 1982</u>
Performing Laboratory/Center:		<u>NAVAIRDEVCE</u>	
Technical Coordinator/Phone:		<u>D. N. DeSimone (215) 451-2187/6/9</u>	
Project Engineer:		<u>J. Z. Lewyckyj</u>	
Contributing Laboratory/Center:		<u>Wright-Patterson Air Force Base, Ohio</u>	
Cognizant SYSCOM Code:		<u>AIR-5311</u>	
CNM Product Area No./Title:		<u>5/Crew Equipment and Life Support</u>	

1. Program Description		a. Objective	b. Technical Approach	c. Goals
<p>a. <u>Objective</u>: To provide both Naval and Air Force crewmembers in high performance aircraft with a jointly designed common anti-G-suit that incorporates the latest anthropometric data base available for a better fitting, more comfortable anti-G-suit.</p> <p>b. <u>Technical Approach</u>: Initiate consolidation efforts to arrive at a joint specification, which subsequently can be used by a single designated procurement agency to more effectively meet all service needs.</p> <p>c. <u>Goals</u>: To maximize the crewmember's inflight comfort and effectiveness and minimize cost.</p>				

2. Justification		a. Problem	b. Payoff	c. Risk
<p>a. <u>Problem</u>: The Navy and Air Force use similar anti-G-suit designs which are procured separately by each service, using two different specifications. Both provide equal protection and meet the same basic requirements. Depending on each services needs cost effective procurements and deliveries limited with a duplication of logistics and support.</p> <p>b. <u>Payoff</u>: Improved comfort and fit with compliances to Tri-Service consolidation requirements.</p> <p>c. <u>Risk</u>: The technical difficulties in meeting the objective are minimal.</p>				

3. Program Coordination	Other Navy <input type="checkbox"/>	USMC <input type="checkbox"/>	Army <input type="checkbox"/>	USAF <input type="checkbox"/>	Tri-Service <input type="checkbox"/>	Other: _____
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Task Title: **USN/USAF Anti-G Garment Standardization** Date: **2 Dec 1982**

4. Performer Funding (\$K)

a. Funding	To Date	FY-83	FY-84	FY-85	FY-86	FY	To Comp	Total
NADC		35.0	45.0	55.0	65.0		30.0	280.0
PFA(s)		25.0		20.0	25.0			70.0
Contracts(s)			50.0	40.0	20.0			110.0
Total		60.0	95.0	115.0	110.0		80.00	460.0

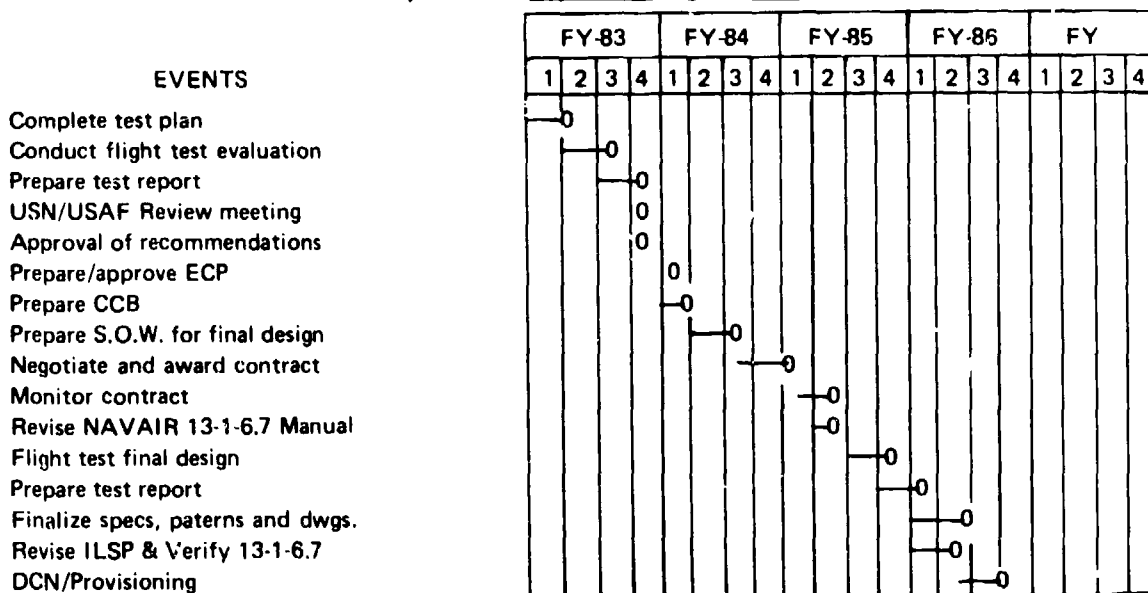
b. Contractors/PFA's	To Date	FY-83	FY-84	FY-85	FY-86	FY	To Comp	Total
NAEC Lakehurst NJ		15.0		20.0	25.0			60.0
NATC Patuxent River, MD		10.0						10.0
TBD			50.0	40.0				90.0
TBD (Tech. Man.)					20.0			20.0

5. Milestones

Start Date: October 1982

Completion Date: January 1984

Projected IOC: September 1984



KEY: 0 Scheduled Event

0 Completed

6. Prepared by:

Jules Z. Lewyckyj

7. Approved by:

D.N. DeSimone

Task Title: USN/USAF Anti-G-Garment Standardization Date: 2 Dec 1982

8. Progress/Accomplishments
New Start

9. Milestones (CFY Expanded)

FY-83

EVENTS

Complete Program Plan
Complete Test Plan
Initiate Flight Tests
Evaluation of Sizing Disparity
Verification of Required Hose Length
for USN A/C
Complete Flight Tests
Prepare Test Report
USN/USAF Data Review Mtg.
Approval of Recommendations from
Review Meeting
Prepare ECP
Forward ECP to NAVAIR

O	N	D	J	F	M	A	M	J	J	A	S
		0									
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Oct. 83

10. Resource Profile (\$K)

	CFY-1	CFY	CFY+1	CFY+2	CFY+3
a. Professional Man-Years		.3	.5	.5	.5
Military Man-Years					
Technical Man-Years					
Shop Man-Years					
Total Direct Labor Man-Years		.3	.5	.5	.5
b. Total Labor & Overhead		33.0	40.0	50.0	60.0
Materials and Travel		2.0	5.0	5.0	5.0
Major Procurement/Contracts		25.0	50.0	60.0	45.0
Planning Estimate		60.0	95.0	115.0	110.0
Funds Available					

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APPENDIX C
AIRCREW QUESTIONNAIRE

AIRCREW QUESTIONNAIRE

NAME/RANK _____ DATE _____
ORGANIZATION _____ AUTOVON PHONE NUMBER _____
AIRCRAFT TYPE _____ CREW POSITION _____
CSU-13/P NUMBER _____ HEIGHT _____ WEIGHT _____
YEARS OF EXPERIENCE WEARING G-SUITS _____
NUMBER OF SORTIES FLOWN WITH THIS G-SUIT _____ HOURS _____
SIZE OF CURRENT G-SUIT (SEE TABLE 1) _____

This questionnaire will be completed by each aircrew member at the end of the 60-day test period. The questionnaire should be completed only after referring to the flight data cards completed on each sortie throughout the test period. Use your current anti-G garment, commonly referred to as a G-suit, as a base line for completing this questionnaire. The following rating scale will be used.

RATING	DESCRIPTION
5	CSU-13/P is a considerable improvement over current G-suit.
4	CSU-13/P is a slight improvement over current G-suit.
3	CSU-13/P shows no improvement over current G-suit (equal).
2	CSU-13/P is slightly worse than current G-suit.
1	CSU-13/P is considerable worse than current G-suit.

1. Rate ease of donning and doffing compared with your current G-suit.

Rating _____

If rating is below "3," please provide comments. Other comments are also solicited.

COMMENTS: _____

2. Compare comfort and fit (too hot, pinching, uneven inflation of abdominal and/or leg bladder, proportional fit, etc.) in inflated and uninflated state with that of your current G-suit.

Rating _____

If rating is below "3," please provide comments. Other comments are also solicited.

COMMENTS: _____

3. Compare G protection with that of your current G-suit.

Rating _____

If rating is below "3," please provide comments. Other comments are also solicited.

COMMENTS: _____

4. Compared to your current Navy G-suit, how do you rate compatibility of the CSU-13/P with other life support, chemical defense (if applicable), and aircraft equipment?

RATING

a. Other life support equipment (list). _____

b. Chemical defense equipment (list if applicable). _____

c. Aircraft equipment (list). _____

If rating is below "3," please provide comments. In addition, if the CSU-13/P was flown with chemical defense or nonstandard life support or aircraft equipment that could affect the test, please comment below. Other comments are also solicited.

COMMENTS: _____

5. Compare durability (seam separation, fabric tears, stuck zippers, etc. due to aging, laundering, abuse).

Rating _____ No. Times Laundered _____

If rating is below "3," please provide comments. Other comments are also solicited.

COMMENTS: _____

6a. Compare the length and the design of the CSU-13/P air supply hose with that of your current G-suit.

Rating: _____

If rating is below "3," please provide comments. If additional length is required for certain planes comment. Other comments are also solicited.

COMMENTS: _____

6b. Compare the design of closure zippers considering such factors as ease of operation, direction of closure, quick release feature, etc. with that of your current G-suit.

Rating: _____

Other comments are also solicited. If rating is below "3," please provide comments.

COMMENTS: _____

6c. Compare the design of the outer shell considering such factors as weight, the leg pockets, velcro sizing, comfort zippers, MC-1 knife pockets, check list retainers, etc., with that of your current G-suit.

Rating: _____

If rating is below "3," please provide comments. Other comments are also solicited.

COMMENTS: _____

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